Vol. 7. SEPTEMBER, 1920 No. 7.

JOURNAL
OF THE
BOSTON SOCIETY
OF
CIVIL ENGINEERS

1848
BOSTON
SOCIETY
OF CIVIL
ENGINEERS

Published monthly, excepting July and August, by the Society,
715 Tremont Temple, Boston, Massachusetts.

Entered as second-class matter, January 15, 1914, at the Post Office at Boston, Mass.,
under Act of August 24, 1912.

Acceptance for mailing at special rate of postage provided for in Section 1103, Act of
October 3, 1917, authorized on July 16, 1918.

Subscription Price, $4.00 a year (Ten Numbers)
50 Cents a Copy

Copyright, 1920, by the Boston Society of Civil Engineers.

BOSTON SOCIETY OF CIVIL ENGINEERS

OFFICERS, 1920-1921

PRESIDENT
FRANK A. BARBOUR

VICE-PRESIDENTS

ROBERT SPURR WESTON (Term expires March, 1921)	**FRANK M. GUNBY** (Term expires March, 1922)

SECRETARY AND LIBRARIAN	TREASURER
S. EVERETT TINKHAM	**FRANK O. WHITNEY**

DIRECTORS

STURGIS H. THORNDIKE (Term expires March, 1921)	**ARTHUR S. TUTTLE** (Term expires March, 1921)
JOHN E. CARTY (Term expires March, 1922)	**HENRY B. WOOD** (Term expires March, 1922)

PAST PRESIDENTS
(Members of the Board)

GEORGE C. WHIPPLE
CHARLES M. SPOFFORD
LEONARD METCALF

NOMINATING COMMITTEE

DAVID A. AMBROSE **HAROLD K. BARROWS** **FRANK A. MARSTON** (Term expires March, 1921)	**WALTER W. CLIFFORD** **HARRY F. SAWTELLE** **DANA M. WOOD** (Term expires March, 1922)

Past PRESIDENTS (Members of the Committee)

HARRISON P. EDDY
CHARLES R. GOW
RICHARD A. HALE

Editor — **WILLIAM L. BUTCHER**
715 Tremont Temple, Boston

Vol. VII SEPTEMBER, 1920 No. 7

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

"Concrete Road Construction." A. N. Johnson.
Memoir of Deceased Member.

Reprints from this publication, which is copyrighted, may be made, provided full credit is given to the author and the Society.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

APPLICATIONS FOR MEMBERSHIP.

[September 15, 1920.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

ETTER, HAROLD PEARSON, Boston, Mass. (Age 23, b. Redding, Calif.). Jan., 1916, to May, 1918, University of California, civil engineering. Jan., 1919, to June, 1920, Mass. Institute of Technology, B.S. degree in C. E, Summer, 1917, rodman with McLoud River R. R. Co., Calif.; summer, 1918, assistant, surveying M. I. T. Summer Camp; summer, 1919, surveying and drafting with J. R. Freeman, Providence, R. I. Since July, 1920, with Stone & Webster, Boston, drafting. Refers to J. B. Babcock, 3d, J. R. Freeman, F. M. Gunby, Leonard Metcalf and C. M. Spofford.

HARSCH, ERWIN, Cambridge, Mass. (Age 25, b. Cincinnati, O.) Graduate Central High School, Washington, D. C., 1911. Graduated from George Washington Univ., 1915, degree of B.S. in C.E. Employed as aid, U. S. Coast and Geodetic Survey, Feb. to Sept., 1913; June to Oct., 1914; and June, 1915, to Sept., 1916. Sept., 1916, to Dec., 1917, instructor in C. E. University of Tennessee. June to Sept., 1917, junior engineer, U. S. Engineer Dept. on Arkansas River Survey. Dec., 1917, to Oct., 1919, ensign (later lieut. j.g.) U. S. Naval Reserve Force. Upon release entered M. I. T. and was graduated June, 1920, with degree of B.S. in C. E. At present, draftsman with Fay, Spofford & Thorndike. Refers to J. B. Babcock, 3d, C. B. Breed, F. H. Fay, H. B. Luther, C. M. Spofford and S. H. Thorndike.

MORGAN, GEORGE BASON, Cambridge, Mass. (Age 24, b. Greenville, Tex.). Graduate Greenville High School, 1913. One year academic work in Burleson College, 1914. Texas A. & M. College, 1914–18, degree of B.S., C. E. With New York Public Service Comm. four months of 1917. Enlisted in U. S. Army, Nov., 1917, College Sta., Texas, C. of E., 2d Lieut., 1918. Discharged, Aug., 1919. At Mass. Institute of Technology Oct., 1919, to June, 1920; received degree B.S., C. E. At present in Managerial Dept. of Stone & Webster. Refers to J. B. Babcock, 3d, E. F. Rockwood, C. M. Spofford and D. M. Wood.

EMPLOYMENT BUREAU.

THE Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society rooms two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

Men Available.

No. 498. Age 28. Has had about six years' experience in construction plant equipment work. Desires position requiring knowledge of the above work or outside work.

No. 499. Age 27. Received certificate from Wentworth Institute. Experience, three years on mold loft drafting; one year as assistant superintendent on construction; two years as assistant master builder; one and one-half years on designing and drafting. Desires position as superintendent or assistant of construction.

No. 500. Age 41. Educated in Boston public schools, English High School and Harvard University, Class 1901; courses in general science and engineering, economics and general culture. Experience, fifteen years with Middle Western Railroad Co.; six years, general surveys, construction, maintenance and betterment; seven years, bridge construction; three years in charge of all surveys, estimates and recommendation for temporary and permanent bridge renewals, especially economic study of choice of type and traffic necessity for light or heavy, temporary or permanent structure. One year, sales engineer for pre-cast concrete of all types. One year, construction and operation on munitions plant. Two years, miscellaneous construction. Desires position on the planning and direction of development and betterment where railroad and concrete experience may be useful, in Boston or vicinity, but will consider any location.

LIST OF MEMBERS.

ADDITIONS.

Brown, O. B. . . . . 104 Boylston St., Watertown, Mass.
Brown, W. I. . . . . 710 City Hall Annex, Boston, Mass.
Clark, W. A. . . . . 109 Pinckney St., Boston, Mass.
Cleverdon, H. S. . . . . 183 Maplewood St., Watertown, Mass.
Cole, H. S. . . . . 16 Winthrop St., Framingham, Mass.
Crandall, J. S. . . . . 44 Sprague St., Malden, Mass.
Dakin, G. W. . . . . 44 Evergreen St., Roxbury, Mass.
Gateley, F. J. . . . . 12 Rowell St., Dorchester, Mass.
Hannan, W. E. . . . . 2 Westmoreland St., Dorchester, Mass.
Holmes, F. O. . . . . 703 City Hall Annex, Boston 9, Mass.
Kinsman, H. L. . . . . 54 Marathon St., Arlington, Mass.

Lynch, D. J. .... 113 Dakota St., Dorchester, Mass.
Monaghan, L. J. .... 45 Stoughton St., Dorchester, Mass.
Morrill, G. P. .... 80 Boylston St., Boston, Mass.
Shaw, E. W. .... 27 School St., Boston 9, Mass.
Sherman, H. A. .... 12 Chauncy Place, Jamaica Plain, Mass.

CHANGES OF ADDRESS.

Borden, J. E. .... 245 Lincoln Ave., Portsmouth, N. H.
Bradbury, E. G. .... 301 Gugle Bldg., Columbus, O.
Caird, A. W. .... 160 South Main St., Florence, Mass.
Carter, G. A. .... Care Parker-Young Co., Wilmington, Vt.
Durham, H. W. .... Care The Foundation Co., Lima, Peru
Foster, H. L. .... 1187 Pingree Ave., West Detroit, Mich.
Hall, W. W., Jr. .... 93 Maplewood St., Malden, Mass.
Hastie, F. B., Capt. .... 318 Engineers, Camp Grant, Ill.
Hering, Rudolph .... 40 Lloyd Rd., Montclair, N. J.
Holway, W. R. .... 230 Lynch Bldg., Tulsa, Okla.
Jonsberg, F. F. .... 16 Central St., Boston, Mass.
King, A. C. .... 53 Railroad Ave., Taunton, Mass.
Lee, E. G. .... 11 Lisbon St., Lewiston, Me.
Monaghan, J. F. .... 79 Milk St., Boston, Mass.
Parke, R. H. .... 11 Thomas St., Fitchburg, Mass.
Pope, Lemuel .... 78 Wyman St., West Medford, Mass.
Probst, A. F. .... 21–25 Pearl St., Boston 9, Mass.
Skillin, F. B. .... 14 North Walnut St., East Orange, N. J.
Stearns, R. H. .... 19 Congress St., Boston, Mass.
Tucker, L. W.,
Care Dwight P. Robinson & Co., 290 Archer St., Freeport, N. Y.
Tucker, H. F. .... Vashon, R.F.D. 1, Wash.
Van der Pyl, Edward,
Campagnie des Meutes Norton, 170 Route de Flandre, La Courneuve, France
Wade, W. N. .... 1242 Commonwealth Ave., Suite 4, Allston, Mass.
Webb, DeW. C. .... Office of Public Works Officer, Navy Yard, Norfolk Va.
Whitman, Ralph .... U. S. Naval Ordnance Plant, South Charleston, W. Va.
Wood, C. W. .... 100 Cambridge St., Winchester, Mass.
Worcester, R. J. H. .... Box A., Somersworth, N. H.

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Antimony in 1919. Henry G. Ferguson.

Alaskan Mining Industry in 1918. G. C. Martin.

Contributions to Economic Geology. Part 2, Mineral Fuels.

Cotton Productions in the United States in 1919.

Deposits of Manganese Ore in New Mexico. Edward L. Jones, Jr.

Fuller's Earth in 1918. Jefferson Middleton.

Graphite in 1918. Henry S. Ferguson.

Gold, Silver, Copper and Lead in South Dakota and Wyoming in 1918. Charles W. Henderson.

Gold, Silver, Copper and Lead in Alaska in 1918. G. C. Martin.

Jack Pine. William Dent Sterrett, Forest Examiner.

Manganese and Manganiferous Ores in 1917. D. F. Hewett.

Mineral Resources of the United States. Part 2, Nonmetals.

Phosphate Rock in 1918. Ralph W. Stone.

Preliminary Report on Mineral Resources of the U. S. in 1918. Statistics assembled by Martha B. Clark.

Petroleum in 1917. John D. Northrop.

Prices of Coal and Coke, 1913–18. C. E. Lesher.

Peat in the Dismal Swamp, Virginia and North Carolina. C. C. Osbon.

Results of Magnetic Observations in 1919. Daniel L. Hazard.

Reconnaissance of the Pine Creek District, Idaho. Edward L. Jones, Jr.

Sodium and Sodium Compounds in 1918. Roger C. Wells.

Slate in 1918. G. F. Loughlin and A. T. Coons.

Structure and Oil and Gas Resources of the Osage Reservation, Oklahoma. C. F. Bowen.

Salt, Bromine and Calcium Chloride in 1918. Ralph W. Stone.

Salt, Bromine and Calcium Chloride in 1918. Ralph W. Stone.

Silver, Copper, Lead and Zinc in the Central States in 1918. J. P. Dunlop and B. S. Butler.

Statistics of Railways in the United States, 1917.

Water-Supply Papers, Nos. 429, 443, 446 and 457.

State Reports.

New Jersey. Annual Report of the Department of Conservation and Development, 1919.

New Hampshire. Annual Report of the Public Service Commission, 1919.

New York. Report of the Metropolitan Sewerage Commission, 1918.

New York. Annual Report of State Engineer and Surveyor, Parts 1 and 2, 1917.

Massachusetts. Annual Report of the Public Service Commission, 1918.

Massachusetts. Annual Report of the State Board of Health, 1918.

Massachusetts. Census of Massachusetts, 1915.

Massachusetts. Report of the Statistics of Labor, 1919.

Massachusetts. Annual Report of the Statistics of Manufactures, 1918.

Massachusetts. Annual Report on the Public Employment Offices, 1919.

Massachusetts. Industrial Review, March, 1920. Vol. 1, No. 1.

Massachusetts. Annual Report of Municipal Finances, 1917.

Massachusetts. Labor Bulletins Nos. 36, 44, 45, 47, 48, 50, 51, 86 and 91.

Municipal Reports.

Bangor, Me. Annual Report of the Bangor Water Board, 1919–20.

Boston, Mass. Annual Report of the Transit Commission, 1919.

Boston, Mass. Report of Finance Commission, 1919.

Brockton, Mass. Annual Report of City Engineer, 1919.

Brockton, Mass. Annual Report Sewage Commissioners and City Engineer, 1919.

Chicago, Ill. Annual Report Department of Public Works, 1915 and 1916.

Chicago, Ill. Report on the Chicago Transportation Problem, Bion J. Arnold.

Chicago, Ill. Maps on the Chicago Transportation Problem. Bion J. Arnold.

Chicopee, Mass. Municipal Register, 1898.

Cincinnati, Ohio. Annual Report of Commissioners of Waterworks, 1902.

Columbus, Ohio. Report of Sewerage Purification, 1905.

Fall River, Mass. Annual Report of the Watuppa Water Board, 1919.

Fitchburg, Mass. Annual Report of Water Commissioners, 1895–1900.

Fort Wayne, Ind. Annual Report of the Fort Wayne City Government, 1908.

Gardner, Mass. Gardner Water Company *vs.* Town of Gardner. 2 vols.

Gloucester, Mass. Gloucester Water Supply *vs.* City of Gloucester. Vols. 7 and 8.

Grand Rapids, Mich. Annual Report of Water Board, 1871–1902.

Laconia, N. H. Annual Report of Board of Public Works, 1919.

Louisville, Ky. Water Reports. Vol. 1. 1861–1875.

Municipal Reports.

Medford, Mass. Annual Report Water and Sewer Commissioners, 1919.

New York, N. Y. Report of Business Transactions, 1917.

New York, N. Y. Report of Business Transactions, 1918.

North Adams, Mass. Annual Report of Officers of City, 1919.

Philadelphia, Pa. Annual Report Department of City Transit, 1918.

Reading, Pa. Annual Report of Bureau of Water, 1916.

Taunton, Mass. Water Commissioners' Report, 1919.

Worcester, Mass. Annual Report of Superintendent of Sewers, 1919.

Miscellaneous.

American Society of Mechanical Engineers, 1920 Year Book.

American Society of Municipal Improvements, Proceedings 1919 Convention.

Barge Canal Bulletins, New York State. Series 1 to 10.

Bridges. John W. and Edward D. Storrs.

Detection of Submarines. Harvey C. Hayes.

Examination of Waters and Water Supplies. J. C. Thresh.

History of Water Supply of Glasgow, Scotland. John Burnet.

Hydraulia. William Matthews. (Lond.)

Industrial Arts Index, 1918. C. G. Noyes and L. D. Teich.

Industrial Arts Index, 1918–19. M. E. Potter and L. D. Teich.

Mineral Production of Canada, 1919. John McLeishm, B.A.

Practical Hydraulics. Thomas Box.

Railroad Curves and Earthworks. C. Frank Allen.

Some Sources of Helium in the British Empire. J. C. McLennan.

Tracts on Hydraulics. (Lond.) Thomas Tredgold.

Transcript of Record, State of New York *v.* State of New Jersey. 5 vols.

LIBRARY COMMITTEE.

Vol. VII SEPTEMBER, 1920 No. 7

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

CONCRETE ROAD CONSTRUCTION.

BY A. N. JOHNSON.*

(Presented January 28, 1920.)

BEFORE passing to the discussion of construction details proper it does not seem out of place to say a word as to the general conditions that control all highway construction.

The large road offerings during last year, and the yet larger ones pending for 1920, compel a consideration of factors that previously did not enter seriously into plans for construction of any type of pavement. But to-day the large amount of work which is to be done makes so great a demand upon all resources, transportation, production of materials, labor and contractors' organizations, that it is imperative that every advantage be taken to conserve and make as effective as possible each of these controlling factors. Of all of them, transportation or car supply is the most limited and will, therefore, control the amount of road actually completed in 1920.

The fact that in the spring there are more open-top cars available than at other times during the year emphasizes the necessity that maximum use be made of all cars that may be available during April and May for the transportation of road-making materials and the storage of the same to be used in construction later in the season. The United States Bureau of Public Roads took the lead last fall in outlining the situation to the state highway departments, urging them to let contracts as early as possible, so that contractors, in turn, would be able to give orders for materials and equipment.

---

* Consulting Highway Engineer, 111 West Washington Street, Chicago, Ill.

Such a program necessitates other changes from our procedure in the past. Payments to the contractor would necessarily have to be made, so that he might receive a due amount for materials that are stored and work that is performed, the results of which would not be available in finished construction until considerably later in the season.

In order to make the most of the limited labor supply, it is necessary that more attention than ever be given to labor-saving devices, and contractor's equipment should be as nicely balanced as possible, so that each operation will coördinate with all other operations that are required and not cause delay because one portion of the work is improperly or insufficiently equipped.

The whole situation is one that must be given very much closer study both on the part of the engineers and the contractors. Each must assume new responsibilities if road production is to be brought to a maximum.

Subgrade. — The employment of machinery makes possible refinements which otherwise would not be practicable. The preparation of the subgrade is an example in point. More study and care should be given this part of the work. I agree with those engineers who have expressed the opinion that the subgrade should receive little or no rolling. This is particularly true for heavy clay and gumbo soils. In general, it is recommended that the subgrade should be brought to within one or two inches of the desired elevation; the side forms should then be accurately set and the remaining portion of the subgrade carefully scraped or honed to the exact contour and elevation. This may be accomplished by a grading machine, recently put upon the market, which may be operated so as to bring the roadbed to as nearly true a surface as is desired for the surface of the concrete, which is as it should be.

On those subgrades, in clay soils particularly, where drainage is especially difficult, and upon certain types of heavy gumbo soils which undergo considerable change with the variations between dry and moist conditions, it is recommended that a layer three or four inches thick, of cinders, sand, fine gravel or similar material, be placed, upon which the concrete is laid.

Broad, flat shoulders will help greatly to minimize movement in the subgrade due both to frost and moisture conditions. Narrow shoulders bordered by deep ditches is a condition to be avoided.

Side Forms. — The use of the subgrading machine which runs upon the side forms emphasizes the necessity for having them carefully placed and solidly constructed. If heavy steel forms, preferably what is known as a ship-angle shape, cannot be secured, then three- or four-inch wood forms are more to be desired than the lighter steel forms that have been used, and which have proved so ineffective.

Joints. — There is an increasing tendency on the part of many engineers to omit entirely expansion joints in the construction of concrete roads, and there has accumulated ample experience to justify such practice. The chief advantage gained by omitting expansion joints is the avoidance of an uneven surface at the joints, which often occurs unless extreme care is taken to place the joint and to finish the concrete surface in the immediate vicinity.

Reinforcement. — The use of larger units of reinforcement, spaced wider apart than has been the custom, is gaining some preference. Particularly has the employment of bars $\frac{3}{4}$ in. in diameter laid along the edge of the pavement and crosswise at intervals of four to five feet, proved to be a very practical and effective method. The use of reinforcement is strongly recommended for those portions of a road where the subgrade drainage is regarded as especially uncertain.

It is the practice in some localities to reinforce all the concrete in all of the roads laid, but it would seem to be a more effective use of the reinforcement if it were omitted over stretches of road which were well drained, and an additional amount, over that used at present, placed in those sections of the road where the greatest difficulty is expected, to obtain good subgrade conditions.

The amount of reinforcement that is used, and that it is practical to use from a cost standpoint, is not sufficient to add appreciably to the cross-breaking strength of a concrete slab.

It is absolutely erroneous, therefore, to consider that reinforcement in anywise replaces concrete and that a thinner slab may be laid with reinforcement than would be laid without it. If the amount of reinforcement were thirty or forty times as much as is customarily employed, there would be some basis for such a contention. Reinforcement is useful, not to prevent the formation of cracks, but to prevent a crack from opening and becoming of any appreciable size; and to this end a small amount of reinforcement is effective.

Coarse Aggregate Tests. — About one third of the state highway specifications for concrete roads prescribe that the coarse aggregate shall have a French coefficient of wear not less than a certain grade, the highest grade prescribed being 12, while other states admit as low as 6 or 7. The French coefficient of wear was designed, as all highway engineers know, to test materials for macadam roads. The effect of traffic on pieces of crushed stone in a macadam road is quite different from that upon pieces of crushed stone imbedded in a concrete road. In the former all the pieces are subjected to wear, — that is, due to the movement that occurs from the passage of a heavy vehicle, the pieces of stone move and rub upon one another, thus creating what is known as internal wear. It is essential, therefore, that pieces of rock having a high resistance to wear should be used, and, because of this, it was seldom advisable to use rock in a macadam road having a French coefficient less than 12 to 14.

But in the concrete road there is no internal wear, and therefore the French coefficient does not offer any criterion as to the adaptability of a given rock for concrete road work. There are many concrete roads which have been made of aggregate having a French coefficient as low as 7, subjected to very heavy traffic and showing after a number of years' service very little wear; no more than many other roads constructed with aggregate having much higher French coefficient of wear. In fact, it can be stated that as between an aggregate having a French coefficient of 7 and one having a coefficient two or three times as great there is no practical difference as to the wearing effect in a concrete road, and that, therefore, there is no reason to exclude rock or pebbles that have a French coefficient as low as 6 or 7.

This point is discussed at some length by H. E. Breed, consulting engineer, New York City.*

Tests of Sand for Organic Impurities. — Too few specifications make provision for testing sand for organic impurities. The test is so simple and can be made so readily by any engineer or foreman in the field that it is entirely practical; and, because it is of the greatest importance that no organic impurities be in the sand, such tests should be required by all specifications.

The test is made by shaking a few ounces of the sand in a 3 per cent. solution of sodium hydroxide and, upon settlement over night, observing the clear liquid which, if colorless or at the most light yellow, indicates freedom of organic impurities; whereas if the liquid is a decided amber or brown it is an indication of an amount of organic impurity which should not be permitted in concrete for road purposes.

But a small amount of organic impurity is sufficient to reduce the strength of the concrete to a third or a quarter of what it would otherwise be. In fact, but a comparatively small amount of organic impurity is necessary to cause complete disintegration of the concrete.

It is oftentimes true that many sands apparently clean will contain organic impurities in sufficient amount to make them dangerous for use in concrete road work. Sands having organic impurities may be washed and in most instances most of the impurity removed, but they should be afterwards tested to make sure there does not remain a harmful quantity.

Consistency. — We have learned from the investigations of Prof. D. A. Abrams, of the Structural Materials Research Laboratory, Lewis Institute, Chicago, that the strength of concrete depends absolutely upon the ratio of the amount of water to the amount of cement, and that the use of more water than is necessary to produce a workable consistency or plasticity is merely wasting cement and producing concrete from one third to one half the strength that it would otherwise have. It is therefore important that our specifications should contain some definite measure of the consistency desired. The majority of specifications at present merely describe the consistency of the concrete without providing any exact measure by which it may be ascertained.

---

* *Municipal and County Engineering*, February, 1920, p. 5.

The slump test using a truncated cone mold has been developed by F. L. Roman, testing engineer of the Illinois State Highway Department, which answers every purpose and may be readily used in the field. The method of making the test consists in filling a thin metal mold in the form of a truncated cone having an 8-in. base, 4-in. top and 12 in. high, with the freshly mixed concrete which is lightly tamped by a rod as the concrete is placed in the mold. As soon as the mold is filled and struck with a trowel it is removed by means of handles on either side, and the height of the concrete after removal of the mold is measured. The difference between this height and the height of the mold, or 12 ins., is taken as the slump. For concrete in concrete road work a practical consistency is obtained when the slump is between ½ in. and 1 in. Less than ½ in. gives too stiff a mixture, while more than 1 in. is unnecessarily wet if the road is to be finished by a mechanical tamping machine. Where the surface of the concrete is struck by a template worked by hand it may be necessary to use a consistency corresponding to a slump of 1½ ins.

In practice, the application of the test will be to mix a batch of concrete, knowing the amount of water used, and make the slump test. Accordingly as the slump measured is too little or too great, more or less water will be used in the succeeding batches.

When the proper consistency has been obtained, as noted by the slump, there is little practical difficulty to secure a similar consistency by merely noting the appearance of the concrete. The consistency which gives the highest strength in the laboratory uses too dry a concrete for practical manipulation, and has a rather mealy-dry appearance; whereas the consistency containing the least amount of water which will give a workable plasticity, and therefore the strongest that can be made in actual work, is one which shows barely a glisten on the particles of the aggregate as they come out of the mixer. If the concrete has an appearance wetter than this, the amount of water is unnecessarily large for practical handling in road work. If no more than 10 or 15 per cent. excess water is used, it has cut down the strength of the concrete by nearly 50 per cent. Too great attention cannot be paid to this important point of controlling nicely the amount of water used in mixing the concrete.

Proportions for Mixing Concrete. — Professor Abrams' investigations have also demonstrated that the effect of variation in the grading of the aggregate upon the strength of the concrete is due to the fact that one grading may require a different amount of water for a given amount of cement than is required for a different grading, to give in each instance the same workable plasticity. From the sieve analyses he has evolved a property of aggregates which he calls the "fineness modulus," which gives a measure of the relative grading of different aggregates. The fineness modulus, he finds, is such a property of the aggregate that two aggregates within reasonable limits of grading with the same fineness modulus will, if mixed with the same amount of cement and water, produce a concrete of similar plasticity, and will in a given time attain the same strength.

He has shown further, based upon the results of many thousands of tests, that, using the same proportion of cement with aggregates of different fineness moduli, and securing in each instance the same plasticity, the strength of the concrete varies as the fineness modulus of the aggregate.

The sieve analysis of a given aggregate being known, the fineness modulus can be computed; and we may then determine the proportion of cement to use to produce a concrete of the desired strength. Thus it is possible and practical to make concrete of equal strength of quite dissimilarly graded aggregates. For example, one aggregate may range from 3-in. pieces to the finer sand particles, while the second may contain no pieces over 1 in. in size. Yet, by varying the proportions of cement, each of these aggregates may be used and the strength of the resulting concrete be the same in each instance.

This fact is of great importance, as we are enabled to use a wide variety of aggregates with regard to sizes and grading. Many supplies of aggregates now excluded by the narrow restrictions of our specifications, may be employed and exactly as good concrete produced as that made under our present specifications. We have been somewhat inclined to develop a standard specification, and have lost sight of the fact that it is not the specification that is to be standard but, rather, the product. If concrete possessing the same strength and durability can be made from aggregates having various gradings and limiting sizes, then there is no reason to adhere to specifications which confine the selection of aggregates to those of a particular grading and exclude all others.

Until we had before us the results of the investigations of Professor Abrams, we could not have said with any precision just what difference should be made in the proportioning of aggregates of different sizes in order to produce concrete of a given strength. This we are now able to accomplish; but it is not necessary here to enter into a further discussion of the principles involved. For those who desire to study the matter more thoroughly, reference may be made to the bulletins of the Structural Materials Research Laboratory, Lewis Institute, Chicago, particularly Bulletin No. 1.

Under our standard specifications to-day for fine aggregate, we are limited to the use of material varying from $\frac{1}{4}$-in. size particles down to the finer materials, specifying that it shall be reasonably well graded between the smaller and larger particles. Suppose, however, there is available a quantity of sand containing no particles larger than $\frac{1}{8}$-in., or possibly containing no particles over 1/14-in., are we to throw away these sands, or may we use them varying the proportions so as to produce the same strength concrete as obtained with the sand containing $\frac{1}{4}$-in. particles?

Our specifications to-day for coarse aggregate, while they vary somewhat more than for fine aggregate, yet restrict the choice of materials to very narrow limits, the sizes usually specified varying from $\frac{1}{4}$-in. particles to 2 in., some as high as 3-in. and a number limiting the larger size to $1\frac{1}{2}$ ins. But we have at hand, let us say, a large amount of material which contains no particles less than 1 in. in size, varying from that to 2 ins. or possibly to 3 ins., or there is other material available

PLATE I.
JOURNAL BOSTON SOCIETY
OF CIVIL ENGINEERS.
SEPTEMBER, 1920.
JOHNSON ON
CONCRETE
ROAD CONSTRUCTION.

ABRAMS' TABLE OF PROPORTIONS AND QUANTITIES FOR ONE CUBIC YARD OF CONCRETE.

Based upon laboratory investigations, using approved materials, compressive strength, twenty-eight days, with workable plasticity, 6- by 12-inch cylinders, 3 000 pounds per square inch.

Sizes.		Fine Aggregates, Screen Openings Per Inch.														
		0-28			0-14			0-8			0-4			0-⅜ in.		
Coarse Aggregates Inches.	Cement, in Barrels Aggregates in Cubic Yards.	Cement	Fine	Coarse	Cement	Fine	Coarse	Cement	Fine	Coarse	Cement	Fine	Coarse	Cement	Fine	Coarse
No. 4 Screen to ¾	Proportions	1	1.3	2.4	1	1.6	2.4	1	1.8	2.3	1	2.0	2.3	1	2.7	1.5
	Quantities	1.96	.37	.69	1.85	.44	.66	1.82	.48	.62	1.75	.52	.59	1.79	.72	.40
No. 4 Screen to 1	Proportions	1	1.3	2.7	1	1.6	2.6	1	1.8	2.6	1	2.0	2.5	1	2.6	1.8
	Quantities	1.90	.36	.76	1.77	.42	.68	1.72	.46	.66	1.67	.50	.62	1.72	.66	.46
No. 4 Screen to 1½	Proportions	1	1.2	3.1	1	1.6	3.2	1	1.7	3.1	1	2	3	1	2.4	2.4
	Quantities	1.82	.32	.84	1.68	.40	.79	1.63	.41	.75	1.61	.47	.72	1.62	.57	.57
No. 4 Screen to 2	Proportions	1	1.2	3.5	1	1.5	3.5	1	1.6	3.7	1	1.9	3.6	1	2.2	3.1
	Quantities	1.75	.31	.90	1.63	.36	.85	1.55	.36	.85	1.52	.43	.81	1.53	.50	.70
No. 4 Screen to 2½	Proportions	1	1.1	3.8	1	1.4	3.9	1	1.6	4.0	1	1.8	4.0	1	2.1	3.5
	Quantities	1.72	.28	.97	1.58	.33	.91	.51	.35	.89	1.49	.40	.88	1.50	.46	.78
No. 4 Screen to 3	Proportions	1	1.1	3.9	1	1.4	4.1	1	1.5	4.1	1	1.7	4.1	1	2.0	3.7
	Quantities	1.69	.28	.97	1.58	.33	.97	1.49	.33	.90	1.49	.37	.90	1.49	.44	.81
⅜ to ¾	Proportions	1	1.3	2.3	1	1.7	2.3	1	1.9	2.3	1	2.2	2.2	1	2.8	1.4
	Quantities	1.96	.37	.67	1.85	.46	.63	1.82	.51	.62	1.75	.57	.57	1.79	.75	.37
⅜ to 1	Proportions	1	1.3	2.6	1	1.7	2.6	1	1.9	2.5	1	2.2	2.4	1	2.7	1.7
	Quantities	1.90	.36	.74	1.77	.44	.68	1.72	.48	.64	1.67	.54	.59	1.72	.68	.43
⅜ to 1½	Proportions	1	1.3	3.0	1	1.7	3.0	1	1.9	3.0	1	2.1	2.9	1	2.6	2.2
	Quantities	1.82	.35	.80	1.68	.43	.75	1.63	.46	.73	1.61	.50	.68	1.62	.63	.53
⅜ to 2	Proportions	1	1.3	3.3	1	1.7	3.4	1	1.8	3.5	1	2.0	3.4	1	2.4	2.9
	Quantities	1.75	.34	.86	1.63	.41	.83	1.55	.42	.80	1.52	.45	.77	1.53	.62	.66
⅜ to 2½	Proportions	1	1.3	3.7	1	1.6	3.7	1	1.7	3.9	1	2.0	3.8	1	2.3	3.3
	Quantities	1.72	.33	.95	1.58	.37	.87	1.51	.37	.87	1.49	.44	.84	1.50	.51	.74
⅜ to 3	Proportions	1	1.2	3.8	1	1.6	3.9	1	1.7	4.0	1	1.9	4.0	1	2.2	3.5
	Quantities	1.68	.30	.95	1.58	.37	.91	1.49	.37	.88	1.49	.42	.88	1.49	.48	.77
½ to ¾	Proportions	1	1.5	2.3	1	1.9	2.2	1	2.1	2.2	1	2.3	2.1	1	2.8	1.3
	Quantities	1.96	.44	.67	1.85	.52	.61	1.82	.56	.59	1.75	.59	.54	1.79	.75	.34
½ to 1	Proportions	1	1.5	2.5	1	1.9	2.5	1	2.1	2.4	1	2.3	2.4	1	2.8	1.6
	Quantities	1.90	.42	.70	1.77	.50	.66	1.72	.53	.61	1.67	.57	.59	1.72	.72	.41
½ to 1½	Proportions	1	1.4	2.8	1	1.9	2.9	1	2.1	2.9	1	2.2	2.8	1	2.7	2.1
	Quantities	1.82	.37	.75	1.68	.47	.73	1.63	.51	.69	1.61	.52	.66	1.62	.65	.51
½ to 2	Proportions	1	1.4	3.3	1	1.9	3.3	1	2.0	3.4	1	2.2	3.3	1	2.7	2.7
	Quantities	1.75	.36	.86	1.63	.46	.79	1.55	.46	.78	1.52	.50	.74	1.53	.62	.62
½ to 2½	Proportions	1	1.4	3.6	1	1.8	3.6	1	1.9	3.7	1	2.1	3.7	1	2.6	3.1
	Quantities	1.72	.35	.91	1.58	.43	.85	1.51	.42	.83	1.49	.46	.81	1.50	.57	.69
½ to 3	Proportions	1	1.3	3.7	1	1.8	3.8	1	1.8	3.9	1	2.1	4.0	1	2.4	3.3
	Quantities	1.68	.33	.92	1.58	.42	.89	1.49	.40	.86	1.49	.46	.88	1.49	.53	.63
¾ to 1	Proportions	1	1.7	2.4	1	2.1	2.4	1	2.4	2.1	1	2.6	2.2	1	3.1	1.5
	Quantities	1.90	.48	.68	1.77	.55	.63	1.72	.61	.53	1.67	.64	.55	1.72	.79	.39
¾ to 1½	Proportions	1	1.7	2.7	1	2.0	2.8	1	2.3	2.7	1	2.5	2.7	1	3.0	2.0
	Quantities	1.82	.46	.73	1.79	.50	.70	1.63	.55	.65	1.61	.59	.64	1.62	.73	.48
¾ to 2	Proportions	1	1.7	3.1	1	2.0	3.1	1	2.3	3.1	1	2.5	3.0	1	3.0	2.4
	Quantities	1.75	.44	.80	1.63	.48	.75	1.55	.53	.72	1.52	.56	.67	1.53	.68	.55
¾ to 2½	Proportions	1	1.7	3.3	1	2.0	3.5	1	2.3	3.4	1	2.4	3.4	1	2.9	2.8
	Quantities	1.72	.43	.84	1.63	.47	.83	1.51	.52	.76	1.49	.53	.75	1.50	.64	.62
¾ to 3	Proportions	1	1.7	3.5	1	2.0	3.7	1	2.3	3.7	1	2.4	3.6	1	2.8	3.1
	Quantities	1.68	.43	.88	1.58	.47	.87	1.49	.51	.81	1.49	.53	.79	1.49	.62	.68
1 to 1½	Proportions	1	1.7	2.8	1	2.0	2.9	1	2.3	2.7	1	2.6	2.6	1	3.1	2.0
	Quantities	1.82	.46	.75	1.68	.50	.73	1.63	.55	.65	1.61	.62	.62	1.62	.75	.48
1 to 2	Proportions	1	1.5	3.2	1	1.9	3.5	1	2.2	3.3	1	2.4	3.3	1	3.0	2.6
	Quantities	1.75	.39	.83	1.63	.46	.85	1.58	.51	.76	1.52	.54	.74	1.53	.68	.59
1 to 2½	Proportions	1	1.4	3.4	1	1.9	3.8	1	2.0	3.7	1	2.3	3.7	1	2.7	3.1
	Quantities	1.72	.35	.86	1.58	.45	.89	1.51	.44	.83	1.49	.51	.81	1.50	.59	.69
1 to 3	Proportions	1	1.3	3.6	1	1.8	4.0	1	2.0	3.9	1	2.2	3.9	1	2.7	3.3
	Quantities	1.67	.33	.90	1.58	.42	.94	1.49	.44	.86	1.49	.48	.86	1.49	.59	.73

containing nothing less than ½-in., and perhaps nothing over 1 in. The question is, can we use such aggregates which vary so widely from our present specifications in such a way as to produce concrete as strong and durable as with the aggregates that comply with our present specifications? From the discussion that has been made of Abrams' work we know the answer to be "yes."

Professor Abrams has prepared a table, which puts the results in a practically available form.

The basis upon which this table has been constructed is the production of a concrete that experience has shown will have sufficient strength and durability for its purpose. There have been many miles of concrete roads built using a 1 : 2 : 3 mixture, with the fine aggregate varying from ¼-in. size material to the finer particles, and the coarse aggregate varying from ¼-in. material to 1½- or 2-in. size pieces. Such a concrete tested under laboratory conditions, using 6 by 12-in. cylindrical test specimens and with a plasticity that secures a practical workability, gives very closely, at twenty-eight days, a compressive strength of 3 000 lbs. per sq. in. This was taken as a basis upon which the table has been prepared.

Five different fine aggregates were selected, varying, as the table will indicate, from the finest which contains no particles over 1/28 in. and others not over 1/14, ⅛, ¼ and ⅜ ins. in size, respectively. A wide selection of coarse aggregates is given, beginning with the first group which has the smaller limit of size at ¼ in., while the larger limit varies from ¾-in. to 3 ins. In the second group the lower limit for the coarse aggregate is ⅜ in., with sizes for the upper limit varying from ¾ in. to 3 ins. Similarly, there are groups with the lower limit at ½ in., ¾ in. and 1 in., respectively, the upper limits in each group varying in sizes to 3 ins., making in all 27 variously sized coarse aggregates; each in turn combined with 5 different fine aggregates or sands, thus making 135 combinations of fine and coarse aggregates, each of which is proportioned so as to produce, under practical working conditions as to consistency, the same strength concrete. In all cases it is to be assumed that all aggregates that are to be used, irrespective of size or grading, are to be of material structurally sound, clean and free of organic impurities.

It should be mentioned that Professor Abrams' tests demonstrated that the resistance to abrasion of concretes varied as the compression strength, — the greater the strength, the greater the resistance to wear; and that concretes of equal crushing strength gave about equal resistance to abrasion.

In the practical application of the table we first have to define how to determine what is the upper limit of size for a given aggregate. Should any sand containing a few ¼-in. particles be classed as one varying from zero to ¼ in., or should there be required a certain percentage of material between the ¼-in. size and the next lower limit, as shown in the table, which is ⅛-in? The proper allowance, Professor Abrams tells us, should be 15 per cent.; that is, a fine aggregate with ¼-in. particles which did not contain 15 per cent. by volume of the material passing the sieve with 4 openings to the inch and retained on a sieve with 8 openings to the inch, should be classed as ⅛-in. sand and not as ¼ in.

The following rule is to be applied to determine the limits of sizes for the coarse aggregate: There shall be not less than 10 per cent. of material between the largest size and the next smaller size shown in the table. Thus a coarse aggregate to be classed as 2½-in. size shall have not less than 10 per cent. of the material between the 2½-in. size and the 2-in. size. If there is less than 10 per cent. between the 2½-in. size and the 2-in. size it should be classed as 2-in. provided there should be at least 10 per cent. of the material retained upon the 1½-in. screen.

The lower limit of size of a coarse aggregate shall be the largest size shown in the table for coarse aggregate, below which there is not to exceed 10 per cent. by volume of the material. Thus a coarse aggregate in which the lower limit of size is to be 1 in. should be an aggregate in which there is not to exceed 10 per cent. by volume of the material passing the 1-in. screen. In all coarse aggregates, if there is to exceed 5 per cent. of the volume passing a ¼-in. sieve, then such excess shall be considered as fine aggregate, and the amount of fine aggregate to be used is to be modified accordingly.

It will be noted that, in addition to the proportions by which to combine the various fine and coarse aggregates with the unit quantity of cement, there is also given the quantities of the materials to be used to make 1 cu. yd. of concrete. These quantities are given in barrels and hundredths of barrels for cement, and in hundredths of cubic yards for the fine and coarse aggregates. The quantities shown do not make any allowance for waste from any source; so that for practical estimates they should be increased from the amounts shown, as experience in handling the work according to the particular method to be employed has indicated as necessary.

The following example will make clear the practical use of the table:

It will be supposed that one sand is that usually specified, from $\frac{1}{4}$-in. down, and must be shipped in at a cost of $2 per cu. yd., and that one coarse aggregate, varying from $\frac{1}{4}$-in. to 2 ins., must also be shipped in at a total cost of $3 per cu. yd.; that there is available locally a supply of sand and coarse aggregate, each being rather fine, the sand varying from $\frac{1}{8}$-in. down, which costs $1.50 per cu. yd., while the coarse aggregate varies from $\frac{1}{4}$-in. to 1 in. and may be secured at a cost of $2.50 per cu. yd. The cement in each case is assumed to cost $3 per barrel. The cost of a cubic yard of concrete using the materials to be shipped in would then be as follows:

1.52 barrels cement	@	$3.00	=	$4.56
.43 cu. yds. of sand	@	2.00	=	.86
.81 cu. yds. of coarse aggregate	@	3.00	=	2.43
Total cost of materials for 1 cu. yd. concrete				$7.85

Using local materials the cost would be:

1.72 barrels cement	@	$3.00	=	$5.16
.46 cu. yds. of sand	@	1.50	=	.69
.66 cu. yds. of coarse aggregate	@	2.50	=	1.65
Total cost of materials for 1 cu. yd. concrete				$7.50

In this instance the local aggregate, although fine and requiring more cement, will produce a yard of concrete at less cost. In general, it will be found that the use of finer sand or of finer aggregate increases the amount of cement, the opposite being true for coarser sizes. Thus a coarse aggregate, with all of the fine material removed, varying from 1 in. to 3 in. in size, combined with sand varying from $\frac{1}{4}$-in. down, uses 1.49 barrels of cement; whereas an aggregate varying from 1 in. to $\frac{1}{4}$ in. combined with the same sand, $\frac{1}{4}$ in. down, requires 1.67 barrels of cement for a cubic yard of concrete.

If the producer of aggregate materials can say what are the sizes of aggregates he can furnish, they can be used to make a concrete of a given strength. Should concrete of a strength other than 3 000 lbs. per sq. in. be desired, then another table would be calculated with the proportions and quantities required accordingly; but the table given here is confined to the use of concrete for concrete roads where a better quality and greater strength are required than is necessary for concrete for many other structures.

A specification to include this table would provide a section somewhat as follows:

Specifications for Proportions Using Abrams' Table. — The proportions of cement, fine and coarse aggregate, for the concrete shall vary according to the sizes of the fine and coarse aggregates to be used, as indicated in Abrams' Table of Proportions and Quantities as printed herewith. One sack of cement is to be considered as 1 cu. ft., and proportions are to be by volume. The quantity of cement in a cubic yard of concrete in place shall be not less than the amount as shown in the table for a given proportion of coarse and fine aggregates.

Before work is started the contractor shall advise the engineer of the particular sizes of fine and coarse aggregates he expects to use, and no change shall be made by the contractor from such sizes except upon due notice in writing to the engineer.

To determine in what classification a given aggregate shall fall, the following method shall prevail:

For fine aggregate there shall be not less than 15 per cent. of the total volume between the coarsest size and the next smaller size shown in the table. Thus, if fine aggregate is to be classed as $\frac{1}{4}$-in., there shall be not less than 15 per cent. of the material between the No. 4 screen and the No. 8 screen.

In coarse aggregate there shall be not less than 10 per cent. of material between the largest size and the next smaller size shown in the table. Thus, a coarse aggregate to be classed as 2½-in. size shall have not less than 10 per cent. of the material between the 2½-in. size and the 2-in. size.

In each instance, whether fine or coarse aggregate, if there is not of the coarser sizes the amounts as here described, the upper limit of size of the material is to be that of the next smaller size. That is, an aggregate that contains some 2½-in. material, but less than 10 per cent. between 2½-in. and 2-in., is to be classed as 2-in. size for the upper limit.

The lower limit of size of a coarse aggregate shall be the size shown in the table for coarse aggregate below which there is not to exceed 10 per cent. by volume of the material.

If there is to exceed 5 per cent. of the volume of coarse aggregate passing the No. 4 sieve then such excess shall be considered as fine aggregate and the amount of fine aggregate to be used shall be modified accordingly.

Aggregate falling between limits of sizes other than shown by the table may be used only upon special written permission of the engineer and in such proportions as he may indicate.

In all cases aggregates both fine and coarse are presumed to be reasonably well graded between the limits specified.

Specifications for Consistency. — The amount of water to be used for mixing concrete shall be that which will give a consistency to be determined as follows:

Newly mixed concrete shall be placed in a truncated-cone shaped metal mold having an 8-in. base, 4-in. top and 12 ins. high. The concrete shall be lightly tamped with a rod as it is placed in the mold, which when filled is to be immediately removed by means of handles on either side of the mold and the slump or settlement of the concrete noted. For concrete to be finished by a mechanical tamping machine, the slump shall not be less than ½-in. nor to exceed 1 in. If the concrete is to be finished by hand methods, the slump may be as much as 1½ ins.

DISCUSSION.

Arthur W. Dean.* — Mr. Johnson's table that he has given is most impressive. Theoretically, I think you will agree with me it doesn't look quite right. Nevertheless, if it has been proven by experiment, it must be considered as being correct.

Mr. Johnson did not cover some matters that may appear small but nevertheless are important; he stated that he should not cover every detail because he expects to have them brought out in the discussions.

First is the matter of foundations. There seems to be, in the minds of some road builders, a tendency to believe that if you have such a solid surface as cement concrete you do not need as much foundation, or as solid a foundation, or a foundation as free from water, as you do if you are building waterbound or bituminous macadam or other similar surface that has more or less elasticity. It has been pretty well demonstrated in practice, however, that you need just as much and as good a foundation and just as much underdrainage for taking care of the subsoil water for a cement concrete surface as you do for any other type of surface.

Some six years ago, if I may bring up a local matter, the Massachusetts Highway Commission was about to build a section of state highway in North Andover. An estimate was made, using about 18 ins. of foundation, under 6 ins. of bituminous macadam. The cost ran up to somewhere in the vicinity of $30 000 a mile, according to that estimate. It was argued that if a concrete surface were used, less foundation and drainage would be necessary, and the cost of concrete surface with alleged sufficient foundation would be less than the cost of bituminous macadam with its necessary foundation. Consequently, what the engineers of the Commission called a "demonstration road," and some others called an "experimental road," was built. Those of you who travel around the country in automobiles, and have been over the road from Lawrence to Salem, may have noticed a mile and a half of road built without much foundation or much drainage, and that road, originally in 30 ft. slabs, is now in slabs from 30 ft. down to slabs of 1 ft. square. The slabs are all there, however. Very little maintenance has been necessary, except to fill the cracks with tar or asphalt, and there has been very little time in the spring of the year when the road is not fairly smooth to drive over. No slabs have had to be entirely rebuilt, but two or three have been partially rebuilt since the road was constructed. Other maintenance was simply to putty up the cracks. While the expense of maintenance has not been large, the method of construction is inadvisable, and the cracks make the surface unsightly. Its designation by the engineers as a "demonstration road" originated at the time it was built, it being their belief that the construction was improper, and the appearance of the road surface surely demonstrates the truth of their belief.

---

* Chief Engineer, Division of Highways, Department of Public Works, State House, Boston, Mass.

Mr. Johnson spoke of the necessity for reinforcement, or, rather, usefulness of it. A portion of that road was built with reinforcement in certain sections, taking sections 100 to 150 ft. long, at various points along the road, in order to get a good comparison between the sections which had been reinforced and those without. An inspection of the road will show that where the reinforcement exists there is a little difference in the size of the cracks; but there are just as many cracks where it was reinforced as there are where it was not reinforced in the adjoining sections. My theory of reinforcement is that it may be excellent for a few years, in keeping the cracks from being quite as wide as if there were no reinforcement, but I think all engineers will agree with me that, with wire-mesh reinforcement, when a crack comes the moisture will get in, and it will not be many years before the wire mesh at that point has rusted out, and then where the crack is there will be no reinforcement. When frost is coming out of the ground or going into the ground, the ground does not rise uniformly, and if your reinforcement is to keep your concrete from cracking, due to loading of the concrete, you don't know whether to provide beam or cantilever. If the reinforcement is placed at the bottom of the concrete you assume you are taking care of it when the load is on the center; but the edges may not be well held up. On the other hand, the center may be held up and not the edges. Reinforcement really appears of no value except to temporarily keep the cracks from spreading.

Mr. Johnson spoke of joints. It has been my observation of these concrete surfaces, that where expansion or contraction joints are placed 30 ft. apart, other additional cracks form in the concrete slabs. Where they are placed 120 ft. apart you have just about the same number of cracks in a 120 ft. single slab as you have in four 30-ft. slabs. Personally, I can see absolutely no advantage of putting in expansion joints, other than what might be put in at the end of a day's work, or a half day's work (the day's work being assumed at 250 to 300 lin. ft.). No matter how carefully you put in these expansion joints you can't avoid a little disagreeable motion when you ride over them with a rubber-tired vehicle. When you ride over a joint that is made by nature, on the other hand, there is not the ridge, depression, or difference in elevation; consequently the road rides smoothly. Hence I should advocate no expansion joints, except, as I said, at the end of a day's work, but let nature make her own joints, because you know she will make them, even if you make artificial ones for her.

MR. E. S. LARNED.* — I want to ask a question in regard to this sand which Professor Abrams used in preparation for this tabulation. In the sizes running from a No. 28 mesh sieve to a $\frac{3}{8}$-in. sieve, is that natural sand or artificially graded sand?

MR. JOHNSON. — It is understood that 0 to $\frac{3}{8}$-in. sand means sand that is graded from the finest material to $\frac{3}{8}$-in. size.

I cannot say positively whether the samples that may have been used were specially prepared or not. It is evident that sands varying from finest particles to $\frac{3}{8}$-in. in size may have a variety of gradings, some of which may have the same fineness modulus, while others will vary. These tables are based upon what might be termed an average fineness modulus, that is, the fineness modulus of average grading of material for the particular limits of size shown. Theoretically, if the fineness modulus varied from the one assumed, then the proportions should also be varied, but practically it is not found necessary to make such fine distinctions. It is hardly likely that there would be a material with the sizes indicated and having the percentages of fine and coarse as prescribed which would have a fineness modulus differing from the one assumed in the construction of the tables sufficient to make necessary any variations in the proportions.

---

* Civil Engineer, 79 Milk St., Boston, Mass.

MR. LARNED. — I don't know what the impression generally might be, which has been conveyed by these figures, but in a way, if I take Mr. Johnson's statement as made, it upsets some pretty well-established opinions we have formed in regard to sand. I can't think that Mr. Johnson means that we shall refer to the bank sand man, or contractor, and learning what he has that we can use it by referring to this table, because a great many sands are absolutely unfit for concrete work, even though they might conform, in a measure, to these granulometric compositions. Sand that runs from zero to No. 28 mesh is a very fine sand. It would naturally produce a weak mortar; and how, with a sample of that sand, you can obtain strength equal to that with the $\frac{1}{4}$-in. sand, and in addition to that use a larger proportion of sand, simply by using a coarser large aggregate, and obtain equal strength, I don't understand.

Of course I fully appreciate the value of these experiments, and I think it is furnishing data of great interest and value to the profession. I do think, however, that when we come to concrete-road construction we are confronted with conditions so far different from laboratory results that we have to consider some other things, and I think if the local sand is tested in the laboratory, in the only way we now have for a basis of comparison, — with standard sand, — Ottawa sand (I think this is a pretty good basis on which to work), — that with all the various combinations that have been worked out, with the various aggregates, fine and coarse, in a practical way, we have come down to a pretty general specification where we can use either a 1 : $1\frac{1}{2}$: 3 mix or a 1 : 2 : 3 mix, if we want a pretty fat concrete; and if it is possible to vary these results in the interest of economy, of course that is desirable, but I think the use of sand itself should be based not alone on its fineness but on the grade of sand to be used with particular reference to its effect upon the early strength of concrete.

Referring to the question of joints, I find a general recognition of the unimportance of contraction joints. I have long regarded them as not only unnecessary, but as a defacement and an element of weakness in a concrete road. As generally constructed, with fabricated mastic or three layers of three-ply paper, which must stand up above the surface of the concrete, this necessitates a split float. The concrete must be brought up to that bulkhead, and in doing so, with concrete of a normally wet consistency, an excessive amount of fine material is brought against the joint line. There is, consequently, more subsidence at that point, due to excessive wetness and fineness, which brings about unevenness; and then, when the jointing material gives out, an open joint from $\frac{3}{8}$ in. to $\frac{3}{4}$ in. develops, which is a weakness, because every time a wheel drops into it the concrete chips off, and then it opens up even wider.

In the matter of finishing concrete, I thoroughly approve of the use of the roller and of the belt. This possesses all the advantages Mr. Johnson has outlined, and is economical to the contractor. He can do the work better and cheaper in that way. There is a knack, however, in the use of the roller. It can't be put on the work too soon, and you can't follow up with the belt too soon. You must wait until the work is just the right consistency to admit of the belt slipping readily, and yet not working too deep into the concrete.

Foundations are one of the most important things, and I am glad to hear that Mr. Johnson emphasizes the necessity of a uniform base. It is a very common thing to-day, in the construction of concrete slabs, to see them put on an earth or gravel road, or on worn-out bituminous macadam. If the road is not too badly worn out, they spend very little time over the base, other than to fill up the irregularities and spread a very light fill on the sides of the road. The crown of the road often is not taken out. I believe that there is danger in this. In Delaware, of course, the soil is different. It runs from clay to fine sand and they use this screeding apparatus, which shaves off the base, is pulled ahead, and with rolling gives a very flat, true surface. I believe that is very desirable. In Massachusetts to-day some engineers are looking with favor upon the use of the sand cushion between the concrete slab and the foundation, whatever it may be, — earth, stone, gravel, or clayey soil. I believe this is a very excellent thing. I think a sand cushion of as little as 1 in. will do away with much of the trouble by frost and moisture action.

I think the question of protecting the surface of the concrete against too rapid drying out is a good thing to consider. I have noticed that too often the specifications are drawn for canvas covers, and then canvas covers are not used. It has been found, if the slab is covered promptly and the covering wetted down promptly, that you get very excellent results. A few years ago I became an amateur contractor. I used for covering purposes a fine material, stone dust, that we later put in the shoulder of the road. We had very satisfactory results. We got no crazing or checking, and I don't believe the results would have been any better with canvas covers, and if we had been forced to use canvas it would have added very materially to the cost of the work.

I think those things should be very carefully considered as reducing the cost of the work. It is very important to keep the cost down to the contractor, and thus, through him, to the municipality.

Mr. Johnson. — I might say a word in addition to Mr. Larned's discussion. This idea that we have, that concrete is made up of mortar and coarse aggregate, is absolutely wrong, if we are going to get the essence of the work of Professor Abrams. Concrete is a mass of aggregates — they may be all of them fine or two of them fine, or anything. The object of the division into fine and coarse is simply to make the thing commercially practicable. Now, it would be better for concrete to have four divisions and thus have better control of the aggregate, and we would then know more nearly, with any given aggregate, just how much of the aggregate we should use. The comparison of sand with Ottawa sand has no significance whatever. The point is, does the sand that we use, with the rock that we have, produce the concrete that we want? And, if we can show that it does, any other comparison is aside from the matter, or useless. I can't give you the basis of all of this work. It would take too long, if I could. But the bulletins Professor Abrams has issued contain the principal portion of it, and if any of you are interested in it they are available and have been republished by the technical press.

In the matter of durability we are assuming that we have good concrete, and hence we can forget the action of traffic on that concrete. Durability depends on climatic action, — movement of the subgrade resulting in cracks. Those are the elements that will determine the life of the road, and not the wear due to traffic. That has been slight, even on roads carrying the heaviest traffic.

MEMOIR OF DECEASED MEMBER.

HENRY MANLEY.*

HENRY MANLEY was born in what was then North Bridgewater and is now Brockton, Mass., on August 31, 1841, and died October 28, 1919, at his home in West Roxbury. His father was Salmon Manley, a substantial farmer, and his mother was Iza

HENRY MANLEY

---

* Memoir prepared by C. Frank Allen, Edward W. Howe and Laurence B. Manley.

Annette Howard. Through his father's mother he could trace his descent from Francis Cooke, one of the *Mayflower* passengers, and again, through his own mother, he was descended from Mary Chilton, who is reputed to have been the first woman from the *Mayflower* to alight on Plymouth Rock.

Among the earliest of his ancestors known to have settled in the Old Colony, was John Howard who came from England, at the age of fifteen, and lived in the family of Miles Standish in Duxbury. The records show him as "able to bear arms" in 1643. When, in 1649, Miles Standish and two others bought from the Indians the site of Bridgewater under authorization from the Old Colony Court at Plymouth, this John Howard became one of the original proprietors of Bridgewater. He was evidently a man of prominence, one of the earliest surveyors of highways, a selectman in 1678, and later, in 1683, a representative to the General Court. At his death he was possessed of 450 acres of land in Bridgewater.

The first Manley of whom a record is extant was William Manley, who left Weymouth to settle in Easton about 1695. Early in the next century his grandson, Daniel, the great-grandfather of Henry Manley, removed to the farm in North Bridgewater, where Henry Manley was born. This farm, with some additions, remained in the family for nearly two hundred years, until it was taken by the City of Brockton for its sewage disposal beds. All the Manleys were farmers of substance and standing in the community and signed themselves "yeomen." They were evidently well educated; the second Daniel Manley, grandfather of the subject of this memoir, was evidently of this type, as many of his accounts and records, written in a beautiful hand, are preserved in the family.

It has frequently been stated that the best crops of New England have been its men; and its best fruits, character. The residents of the Old Colony, from its earliest settlements, have been among those to whom is due, in large measure, the leadership which the Commonwealth of Massachusetts early exerted in religion, education and industry.

It was Henry Manley's good fortune to be born and brought up on a New England farm, an unrivaled school for the development of industry, resourcefulness and self-reliance. In so far as engineering consists of providing suitable means for meeting existing conditions, a farm offers opportunity for the development of engineering qualities.

The early education of young Manley differed little from that of other boys. He stood well in the "district school" characteristic of his time. Even then, note was taken of the originality of thought so characteristic of him. When he was eleven years old, his father died as the result of an accident. Farm work under his older brothers proved more irksome to him than while his father was living. A fondness for learning led him, at the age of sixteen, to apply for entrance to the State Normal School at Bridgewater, but it was found that he was a year too young. The outcome was that he attended Bridgewater Academy for a year. Here he met the principal's son, Francis T. Crafts, who became his lifelong friend, his army chum and companion in his later travels. Manley then entered the Normal School, from which he was graduated in 1860. Following this, he spent about two years in teaching.

When the Civil War came on, Henry Manley, at the age of twenty-one, enlisted in Company K of the Third Massachusetts Volunteer Militia, being mustered in on September 23, 1862, and mustered out on June 26, 1863. His father had served for a time in the War of 1812. Three of his ancestors were in the Colonial militia during the American Revolution. The regiment saw service in North Carolina, in the battles of Kingston, Whitehall and Goldsborough. It did not see excessively bloody service, but the long marches and the southern climate seriously affected Manley's health, so that with his friend Crafts he took a long sea voyage, landing at Cape Town, South Africa. At Port Elizabeth, and later at Uitenhage, they engaged in a photographic business. A fire finally put a stop to this, and led to his leaving South Africa after spending about a year there.

Mr. Manley returned to take up teaching again for a time, but he had decided to become a civil engineer, and, in 1866, he entered the office of J. Herbert Shedd, in Barrister's Hall, Court Square, Boston, a site now occupied by Young's Hotel. This office was, perhaps, the most important in the city at that time, and offered the best training for prospective engineers. An " apprentice " system was then in force, the pay scheme being one dollar per day for the first year; one dollar and a half the second; two dollars for the third year. This payment per day was for ten hours, provided one had work. There was a " tuition " charge of one hundred dollars per year whether there was work or not. Many well-known engineers had their training, in whole or in part, in this office. While connected with Shedd's office, Manley went to Providence upon the preliminary survey for the water works, of which J. Herbert Shedd later became chief engineer.

During his stay in this office he was loaned for a time to the city engineer of Boston. The outcome was that in the spring of 1869 he was permanently transferred to the office of the city engineer of Boston and remained in that service until his retirement, forty-two years later.

His earliest work of importance with the City of Boston was making surveys for supplying water to Roxbury and Dorchester, both of which had recently been annexed to Boston; and later came surveys for the extension of the water service to Deer Island.

He made surveys for, and had charge of the construction of the sea walls on Atlantic Avenue, from Broad Street to Commercial Street at Eastern Avenue, and also had charge of construction of numerous wharves and bridges, among them the Federal Street Bridge to South Boston, the Chelsea Street Bridge from East Boston to Chelsea, the bridge on the extension of Congress Street to South Boston, and the rebuilding of the Broadway Bridge across Fort Point Channel.

In 1873, when Joseph P. Davis became city engineer, he assigned Manley to the work of surveys and examinations of all the bridges within the city limits. This included making plans of many bridges of which there had been no record in the office. In 1877, he was assigned to the examination and repairs of the bridges of the city, and continued in that work until 1891.

Following an act of the legislature providing that a large proportion of the cost of street construction should be assessed upon the abutting property, an extensive program of street improvement was entered upon, and it fell to the engineering department to take care of the surveys, preparation of plans and specifications, together with supervision of construction. Manley was put in charge of this work in 1891, and continued to be connected with it until his retirement in 1910. He was retired with a pension under a city ordinance applying particularly to veterans of the Civil War. During his connection with the City he found opportunity for more or less private practice in various parts of New England.

Mr. Manley was one of the group that started a society of civil engineers in Boston in May, 1873, and was elected one of the vice-presidents of that society. When it appeared, after a few meetings had been held, that there already existed, although then dormant, "The Boston Society of Civil Engineers," chartered in 1851, he was one of a committee of inquiry into the situation. The outcome was a revival of the old society, the members of which met and took into their society all those who had become members of the new society; this was in June, 1874.

He was treasurer of the Boston Society of Civil Engineers from 1880 to 1892, when he was elected president. He was also elected a director for two years, immediately following his presidency. For twenty-six consecutive years Manley was each year elected by general consent "the committee" to arrange for the annual dinner. This extended from the first annual dinner in 1883 up to and including 1908, after which a new scheme for the annual meeting and smoker at the City Club brought about a new order of things. His election to the presidency by a large majority, at a time when three nominations were necessary, was an evidence of his popularity and an appreciation of his long and efficient service to the Society.

Of several papers before the Boston Society of Civil Engineers, the most interesting and important was that on "Rapid Transit in Boston," presented in 1889, which was very fully discussed. Another paper, in 1893, "The Influence of his Profession upon the Social Relations of the Engineer," was part of a series on Engineers' Relations. Still another, in 1903, was again one of a series dealing with Street Railway Tracks, and was entitled, "The Relation of Street Railway Tracks to the Paving of City Streets."

He was a charter member of the Massachusetts Highway Association, organized in 1893, and its president in 1896. The Connecticut Highway Association, at Springfield, in 1897 elected him an honorary member in recognition of his " kindly influence " " upon the affairs of the association."

In 1880, he joined the American Society of Civil Engineers, and was a director of that society, 1898–1900. When this society joined with the other national engineering societies for a trip to Europe in 1889, Manley and his wife were members of the party; a trip to Europe was at that time an event.

Manley was an examiner for the Civil Service Commission of Massachusetts for inspectors from 1891 to 1913, and on civil engineer grades from the beginning in 1897 to 1913.

His work here, as elsewhere in engineering, was marked by a strong fund of "common sense," upon which in large degree his success as an engineer was based. He was, however, by no means deficient in education. In his time, engineering schools were barely in evidence. But, starting on the farm, carrying his formal education beyond the academy or high school, through the normal school, teaching several years, spending nearly a year in the army, and a year away from New England in South Africa, he was educated well beyond the limits of most of his contemporaries in engineering.

He attended the Unitarian Church at West Roxbury, was its treasurer for thirteen years, and when the Church was moved was chairman of the Building Committee for what is now used as the parish house, but was for many years occupied as the church. He was a member of the Committee on the Memorial Window, served at various times as auditor, and was a trustee of the "Bradford Fund" for thirteen years. He was also a member of the Unitarian Club meeting in Boston, and at its dinners wisely took care to sit next to strangers, rather than old friends, in order to extend his acquaintance.

Manley was an early member of the local Highland Club of West Roxbury, where he is well remembered by his friends as a devotee of the pool table. He was at one time treasurer of the club. He was also among the early members of the Boston City Club.

He was interested in his family history and became a member of the New England Historic Genealogical Society. He also had a part share which entitled him to the use of the Boston Athenæum. After his retirement he found our Society's library, the City Club, the Athenæum, and the Genealogical Rooms, convenient places for the enjoyment of his leisure hours.

He was a member of Charles W. Carroll Post No. 144, Grand Army of the Republic, located at Dedham. In the History of the Third Regiment, he contributed the chapter on Company K, of which he had been a member. He was also a Mason, the degree of Master Mason being conferred by Revere Lodge of North Bridgewater in 1863, from which he demitted in 1872, and for a time was a member of Good Samaritan Lodge of Reading.

On November 6, 1867, he was married to Susan Elizabeth Marshall, of North Bridgewater, where they started housekeeping in their native town. The following year they moved to Brighton, and shortly after bought a house in Reading. In 1875, they moved to Boston on account of Mr. Manley's employment by the City, and settled on Mt. Vernon Street, in the newly annexed suburb of West Roxbury, which was to be their home for the remainder of their lives. They had four children, — a daughter, who died in infancy, and three sons, all of whom became engineers. The oldest, Laurence B. Manley, and the youngest, Henry Manley, Jr., are members of this Society. The other son, Howard T. Manley, has been several years a resident of Mexico. Mr. and Mrs. Manley lived most happily together for nearly fifty-two years. Mrs. Manley survived him by less than two months.

Henry Manley, to his friends, was a delightful companion, pointed and quaint in his sayings and ways of doing; a typical Yankee, keen in his ways of accomplishing things. Many anecdotes might be given for illustration if this were the appropriate place. He was a good friend and neighbor, a worthy citizen, ever faithful and efficient in the many duties entrusted to him.

Among his effects were found the following verses copied by him in 1912 from "Recollections of a Lucknow Veteran 8145–1876, by Major General John Ruggles." It is thought that he had some intention of reading them at one of the Annual Dinners, and that they may fittingly serve as a personal message to his lifelong friends in the Boston Society of Civil Engineers.

" Good-night! I am old and my blood has grown cold,
I am weary of banquet and ball;
I have shared of your best, I would go to my rest,—
Good-night to you, gentlemen all!

" From the laughter and light, I must ride through the night,
Alone from your festival hall;
Looking back through the years with no tremors or fears,—
Good-night to you, gentlemen all!

" Spur at heel, sword at side, as a man I will ride
With no dolorous trappings or pall;
No tolling of bell, but a smile for farewell,—
Good-night to you, gentlemen all!

" Fair ladies, adieu! my obeisance to you;
One kiss, lightly blown, to recall
The hey-day of life, with its love and its strife,—
Fair ladies, good-night to you all!

" The Recorder from whom no man's secrets are hid
Has called me; I go at his call.
I am ready to answer for all that I did,—
Good-night to you, gentlemen all!

" Good-night! then good-night! Though your fires burn bright,
With your lusters ablaze on the wall,
Yet the stars are agleam on the ford at the stream,—
Good-night to you, gentlemen all! "

ADVERTISEMENTS

Vol. VII SEPTEMBER, 1920 No. 7

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

INDEX TO ADVERTISERS.

	Page
A. B. See Electric Elevators, 111 Devonshire St., Boston	VI
Aberthaw Construction Co., 27 School St., Boston	XIV
Adams, H. S., 108 Ames Building, Boston, Mass.	V
Aspinwall & Lincoln, 3 Hamilton Pl., Boston	V
Associated Architects Printing & Supply Co., 21-27 Pearl St., Boston	XIV
Bay State Dredging and Contracting Co., 62 Condor St., East Boston	XVIII
Beattie, Roy H., 10 Purchase St., Fall River	XIII
Bethlehem Steel Bridge Corporation, Bethlehem, Pa.	XVI
Bishop, J. W., & Co., 683 Atlantic Ave., Boston	VI
Blair, Isaac, & Co., Inc., 433 Harrison Ave., Boston	IV
Coleman Bros., 1 Marginal St., Chelsea	XIII
Conant Machine Co., Concord Junction, Mass.	XIII
Donoghue, P. W., 170 Purchase St., Boston	XV
Eastern Bridge and Structural Co., Worcester	XI
Fay, Spofford & Thorndike, 15 Beacon St., Boston	V
Fort Hill Press, 176 High St., Boston	XIV
Fuller, George W., 170 Broadway, New York	V
Gow, Charles R. Co., The, 166 Devonshire St., Boston	XII
Hall, John G., & Co., 114 State St., Boston	XIII
Holbrook, Cabot & Rollins Corpn., 6 Beacon St., Boston	VIII
Holzer, U., 25 Bromfield St., Boston	IX
Hughes, Edward F., 8 Oliver St., Boston	XIII
Kearns Co., W. F.	XIX
Ledder & Probst, 21–25 Pearl St., Boston	XIII
Ley & Co., Inc., Fred T., Springfield, Mass.	III
Main, Charles T., 201 Devonshire St., Boston	IV
Metcalf & Eddy, 14 Beacon St., Boston	V
New England Foundation Co., Inc., 70 Kilby St., Boston	XIII
New England Sand & Gravel Co., West Peabody, Mass.	IX
Old Corner Book Store, 27 Bromfield St., Boston	XIII
Palmer, John E., 1012 Old South Bldg., Boston	XIII
Penn Metal Co., 65 Franklin St., Boston	VI
Pennsylvania Cement Co., 161 Devonshire St., Boston	XII
Perrin, Seamans & Co., 57 Oliver St., Boston	IX

CONTRACTORS
LEY
SPRINGFIELD
MASS.

CAMP DEVENS WAS READY!

Army Cantonment at Ayer, Mass., Completed on Schedule Time

Demonstrating the Wisdom of awarding this Contract on a Cost Plus Percentage Basis

The 622 Buildings whose completion our schedule called for by September 1 were ready for the troops, and many of them occupied.

And 124 Buildings in Addition, including 46 of the 59 buildings needed for the 1,000-bed hospital unit, costing $500,000; refrigerating plants, storehouses, bakeries and miscellaneous buildings — all these completed ahead of schedule time.

Completing This $6,000,000 Contract on Schedule Time Necessitated:

- A Force of 9,000 Men
- A Weekly Payroll of $400,000
- $750,000 in Ready Cash
- Finishing One Building Every Forty Minutes for Two Months
- The Delivery of 30 Million Feet of Lumber
- Unloading 50 Carloads of Materials Daily
- Building a Complete Water Supply System with 20 Miles of Pipe
- Building a Complete Sewerage System with 20 Miles of Pipe

Capt. Canfield, in command of the Ayer Camp, informing us that Ayer headed the list of cantonments in percentage of completion, writes:

"This distinction should be a source of great gratification to your organization, as it is to mine."

FRED T. LEY & CO., Inc.
Contractors
BOSTON SPRINGFIELD NEW YORK

	Page
Raymond Concrete Pile Co., 80 Boylston St., Boston	xvii
Rideout, Chandler & Joyce, 178 High St., Boston	xiii
Rockport Granite Co., Rockport, Mass.	vii
Seeley & Lawson, 73 Tremont St., Boston	vi
Simpson Bros. Corpn., 166 Devonshire St., Boston	vii
Smith, B. F., & Co., Merchants Bank Building 30 State St., Boston	xiii
Stone & Webster, 147 Milk St., Boston	x
Stuart, T., & Son Co., Newton, Mass.	xviii
Thompson, Sanford E., 136 Federal St., Boston	v
Thorpe, Lewis D., 201 Devonshire St., Boston	v
Tucker, Edward A., Co., 101 Milk St., Boston	vii
Turner Construction Company, 178 Tremont St., Boston	xv
Waldo Brothers and Bond Co., 181 Congress St., Boston	xi
Warren Foundry and Machine Co., 11 Broadway, New York	ix
Weston & Sampson, 14 Beacon St., Boston	v
Whitman & Howard, 220 Devonshire St., Boston	v
Worcester, J. R., & Co., 79 Milk St., Boston	v

GEO. A. BLAIR L. L. STREET W. O. WELLINGTON

ISAAC BLAIR & CO., Inc., General Contractors

Shoring and Moving Buildings a Specialty

433 Harrison Avenue, BOSTON

PROFESSIONAL CARDS

CHAS. T. MAIN

ENGINEER

201 Devonshire Street, Boston, Mass.

Rooms 817-833

Plans and Specifications for the erection and equipment or reorganization of textile mills and other industrial plants, including steam and water-power plants

H. S. ADAMS
Consulting Engineer
108-9 AMES BUILDING
BOSTON, MASS.

SANFORD E. THOMPSON
M. Am. Soc. C. E. M. Am. Soc. M. E.
Consulting Engineer
Design of Steel and Reinforced Concrete; Review of Plans; Estimates and Appraisals; Tests of Cement and Concrete; Organization of Construction and Industrial Work.
OFFICES AND LABORATORY
136 FEDERAL STREET, BOSTON

ASPINWALL & LINCOLN
Civil Engineers
3 HAMILTON PLACE
BOSTON

LEWIS D. THORPE
Civil and Sanitary Engineer
Water Works, Sewerage and Sewage Disposal
Supervision of Construction and Operation
201 Devonshire Street
BOSTON, MASS.

FAY, SPOFFORD & THORNDIKE
Consulting Engineers
BRIDGES AND OTHER STRUCTURES OF STEEL AND MASONRY. FOUNDATIONS. RIVER AND HARBOR WORKS
FREDERIC H. FAY CHARLES M. SPOFFORD
STURGIS H. THORNDIKE
15 Beacon Street, Boston, Mass.

WESTON & SAMPSON
ROBERT SPURR WESTON G. A. SAMPSON
Laboratory for the Analysis of Water, Sewage, Filtering Materials, etc., Design, Inspection and Supervision of Water Purification and Sewage Disposal Plants.
14 BEACON STREET, BOSTON, MASS.

GEORGE W. FULLER
M. Am. Soc. C. E. M. Am. Inst. Cons. E.
Consulting Hydraulic Engineer and Sanitary Expert
JAMES R. McCLINTOCK
Water Supply and Purification, Sewerage and Drainage, Disposal of Sewage and Refuse, Investigation of Epidemics, Public Utilities Valuations, Supervision of Construction and Operation.
170 Broadway, New York, N. Y.

WHITMAN & HOWARD
Civil Engineers
(Established in 1869)
220 Devonshire Street Room 504
BOSTON

J. R. Worcester E. E. Pettee G. H. Brazer
MEMBERS OF AM. SOC. C. E.
J. R. WORCESTER & CO.
Consulting and Designing Engineers
Bridges Foundations
Steel and Reinforced Concrete Construction
79 MILK STREET, BOSTON
Cement Testing Laboratory at Waltham, Mass.

METCALF & EDDY
Leonard Metcalf Harrison P. Eddy
Charles W. Sherman Almon L. Fales
Frank A. Marston
CONSULTING ENGINEERS
Water Supply and Sewerage
14 BEACON ST. BOSTON, MASS.

ROLLING STEEL SHUTTERS
COUNTERBALANCED ELEVATOR DOORS
SEELEY & LAWSON
73 TREMONT ST., BOSTON
HOLLOW METAL : DOORS AND WINDOWS : KALAMEIN
Telephone, Haymarket 3790

NEW YORK
101 Park Avenue

BOSTON
683 Atlantic Avenue

J. W. BISHOP COMPANY
GENERAL CONTRACTORS

PROVIDENCE
617 Butler Exchange

WORCESTER
109 Foster Street

More than 50 Years of Service

METAL LATH
CORNER BEAD
CONCRETE REINFORCEMENT
METAL ROOFING AND SIDING
CULVERT PIPE
BOXES, TANKS, LOCKERS
BINS, SHELVING, PARTITIONS
AND ALL FORMS OF
SHEET METAL, STAMPED,
FORMED OR WELDED

USE HAMPTON METAL
"IT WATCHES OTHERS RUST"

Penn Metal Company
65 Franklin Street
Boston, Mass.

OFFICE AND FACTORIES
BOSTON JERSEY CITY PHILADELPHIA
PORTLAND, MAINE

A. B. SEE
ELECTRIC
ELEVATORS
Established 1883

ELECTRIC ELEVATORS OF ALL TYPES

OFFICES
New York
Boston
Hartford
Jersey City
Philadelphia
Washington
Baltimore
Cleveland
Montreal
Toronto

WORKS
Jersey City
New Jersey

Montreal
Canada

BOSTON OFFICE
Minot Building
111 Devonshire St.

SIMPSON BROS. CORPORATION

TRADE MARK REG.
LAID BY SIMPSON BROS.
CORPORATION
166 DEVONSHIRE ST.
BOSTON

ENGINEERS AND CONTRACTORS
FOR
REINFORCED CONCRETE
CONSTRUCTION

ROCK ASPHALT FLOORS — GRANOLITHIC FLOORS.
SIDEWALKS, CURBING, STEPS, BUTTRESSES, ETC.
SIMBROCO CONCRETE STONE BUILDING TRIM.
HASSAM CONCRETE STREET PAVEMENT.

ROCKPORT GRANITE
permanently resists all action of Sea Water

It is an undeniable fact that chemical changes take place in the cement of CONCRETE construction exposed for any number of years to sea water, changes that are certainly not for the better.

No changes take place in Rockport Granite. It is permanent, and it is impermeable; and these FACTS are beyond question. The same facts apply to masonry work of every description — Rockport Granite is the ONE material of PERMANENCY.

A combination of Quality and Low Price is offered in Rockport Granite, full details of which will be supplied upon request. Write.

ROCKPORT GRANITE CO. - Rockport, Mass.
C. HARRY ROGERS, Treas. and Gen'l Mgr.

Branch Offices
Boston, New York City, Chicago, Detroit, Cleveland and Philadelphia

EDWARD A. TUCKER COMPANY
Concrete Engineers

Designs and Estimates Submitted for Concrete Reinforcement — Monotype Deformed Bars — Spirals — Metal Forms

CONVERSE BUILDING, 101 MILK STREET, BOSTON
Direct Mill Connections Warehouse, Cambridge Shop, Camden, N. J.
Telephone, Fort Hill 1840

Holbrook, Cabot & Rollins Corp'n

Contractors

Heavy Masonry and Concrete Construction, Deep Foundations

6 BEACON STREET BOSTON, MASS.

52 Vanderbilt Avenue
New York, N. Y.

JAMES W. ROLLINS, President
FREDERICK HOLBROOK, Vice-President
WILLIAM S. PATTEN, Vice-President
THOMAS B. BRYSON, Secretary and Treasurer

NEW ENGLAND SAND AND GRAVEL CO.

PEABODY 244 WEST PEABODY, MASS.

SCREENED, SIZED AND WASHED

BANK SAND AND GRAVEL

ONE CAR OR A TRAINLOAD

CONCRETING, GRANOLITHIC AND ROOFING GRAVEL
BUILDING AND CONCRETE SAND

PROMPT AND RELIABLE SERVICE

WARREN FOUNDRY AND MACHINE CO.

MANUFACTURERS OF

Cast Iron Gas and Water Pipe

FLANGE PIPE *SPECIAL CASTINGS*

201 Devonshire St.,
BOSTON, MASS.

SALES OFFICES

11 Broadway,
NEW YORK

PERRIN, SEAMANS & CO.

Machinery, Tools and Supplies
FOR
Construction Work

57 OLIVER STREET, BOSTON

U. HOLZER,

BOOK-BINDER

25 Bromfield St., Boston, Mass.

ESTABLISHED 1870.

All kinds of Books bound and repaired.
Maps and Charts mounted.
Portfolios, Scrap Books, Blank Books, etc., made to order.
Lettering in Gold; Paper-Splitting; Inlaying; etc.
Photographs Mounted on Card or Paper without Cockling.

Telephone
and
Elevator

STONE & WEBSTER

FINANCE public utility developments.

BUY AND SELL securities.

DESIGN steam power stations, hydro-electric developments, transmission lines, city and interurban railways, gas plants, industrial plants and buildings.

CONSTRUCT either from our own designs or from designs of other engineers or architects.

REPORT on public utility properties, proposed extensions or new projects.

MANAGE railway, light, power and gas companies.

NEW YORK BOSTON CHICAGO

EASTERN BRIDGE
— AND —
STRUCTURAL CO.

Worcester, Massachusetts,
For Prices on all Classes of

STEEL AND IRON WORK.

WE DESIGN AND MANUFACTURE
ROOF TRUSSES, GIRDERS, COLUMNS, STAIRS
AND FIRE ESCAPES FOR BUILDINGS . . . .

FOOT BRIDGES, HIGHWAY BRIDGES, RAILROAD BRIDGES

We Carry a Large Stock of
I-BEAMS, PLATES AND ANGLES

Can Make Quick Deliveries. Send in Your Inquiries.

WALDO BROS. AND BOND COMPANY

Building Material and
Construction Equipment

181 CONGRESS STREET, BOSTON, MASS.

THE EXTREME HIGH QUALITY OF

PENNSYLVANIA PORTLAND CEMENT

MAKES ITS USE ESSENTIAL WHERE
WORK OF THE HIGHEST CLASS IS DESIRED

PENNSYLVANIA CEMENT CO.

NEW YORK OFFICE
30 East 42d St.

BOSTON OFFICE
161 Devonshire St.

THE CHARLES R. GOW COMPANY

Contractors for Engineering Construction

No. 166 DEVONSHIRE STREET

BOSTON, MASS.

EDWARD F. HUGHES
Artesian and Driven Wells
for
Manufacturing, Public or Private
Water Supply
954 Oliver Building, 8 Oliver Street, Boston, Mass.
TEL. 1633 MAIN

SCIENTIFIC BOOKS
AND PERIODICALS

THE OLD CORNER BOOK STORE
27-29 Bromfield Street
BOSTON, MASS.

Gravel – Sand – Crushed Stone
LOADING MACHINES
For Sale and Rent to
Contractors, Road Builders,
Sand and Gravel Dealers . .
BUILT BY
CONANT MACHINE CO.
Concord Junction, Mass.
Write, call or phone, for information, prices and circulars

JOHN G. HALL & CO.
114 STATE STREET, BOSTON
=PILING=

JOHN E. PALMER
Contracting Engineer
Contractor for Sewers, Water Works,
Concrete Bridges, Concrete
Foundations, etc.
Room 1012, Old South Building
Boston, Mass.
Telephone, Fort Hill 1731

LEDDER & PROBST, Inc.
21-25 PEARL STREET, BOSTON, MASS.
Surveying Instruments
REPAIRING
BLUE AND BLACK PRINTS

Drawing Materials

C.D. Kirkpatrick, *Mgr.* S.P. Gates, *Asst. Mgr.*
B. F. SMITH & CO., INC.
ESTABLISHED 1878
ARTESIAN AND DRIVEN WELLS
FOUNDATION BORINGS
Engineers and Contractors for Municipal and Private Water Works
Office: MERCHANTS BANK BUILDING
30 STATE STREET, BOSTON, MASS.

RIDEOUT, CHANDLER & JOYCE
Engineers and Piping Contractors
178 HIGH STREET - BOSTON, MASS.

Steam Specialties, Engineers' Supplies
Piping of All Kinds Furnished or Erected

New England Foundation Co., Inc.
Engineering and Construction
Simplex Concrete Piles
70 KILBY STREET :: :: BOSTON, MASS.

ROY H. BEATTIE
Harbor Improvements
Divers :: Lighters
10 PURCHASE STREET
FALL RIVER, MASS.

COLEMAN BROS.
General Contractors

Main Office
1 Marginal St.,
Chelsea

Boston Address
166 Devonshire St.

Associated Architects Printing & Supply Co.

NEW LOCATION BETTER AND LARGER QUARTERS

21-27 Pearl Street, Boston

BLUE, BLACK AND VANDYKE PRINTS
GELITHO REPRODUCTIONS
SUPPLIES

Telephones, Main 8482 and 8483, Connecting All Departments

ESTABLISHED 1881

The Fort Hill Press

Our Motto
Quality and Service

SAMUEL USHER

BOOK : JOB : MAGAZINE : CATALOGUE
SCHOOL : LAW

PRINTING

DESIGNING ENGRAVING

TELEPHONE CONNECTION

176 TO 184 HIGH ST., BOSTON

Knowledge of

Engineering Design
Estimating
Planning of Operations
Purchase and Supply
Labor and its Right Guidance
Cost Accounting
Essential Control

Combined in a single homogeneous organization, adequately financed, is the

POWER behind ABERTHAW ACCOMPLISHMENT

ABERTHAW CONSTRUCTION COMPANY
BOSTON MASSACHUSETTS

ATLANTA PHILADELPHIA BUFFALO

6-94

W. B. Knowlton, Engineer AMERICAN WOOLEN COMPANY, Washington Mills, Lawrence, Mass. 264,070 sq. ft.

Turner Construction Company

New York, Buffalo 178 Tremont St., Boston, Mass. *Philadelphia, Atlanta*

P. W. DONOGHUE

Plumbing Contractor

FOR THE

$28,000,000

Boston Army Supply Base

170 Purchase Street

BOSTON, MASS.

Telephone: Fort Hill 4974

Bethlehem Steel Bridge Corporation

BETHLEHEM, PA.

Design Fabricate Erect

STEEL BRIDGES

and other Steel Structures

OFFICES:

NEW YORK, N. Y.
111 Broadway

BOSTON
141 Milk Street

PHILADELPHIA
Morris Building

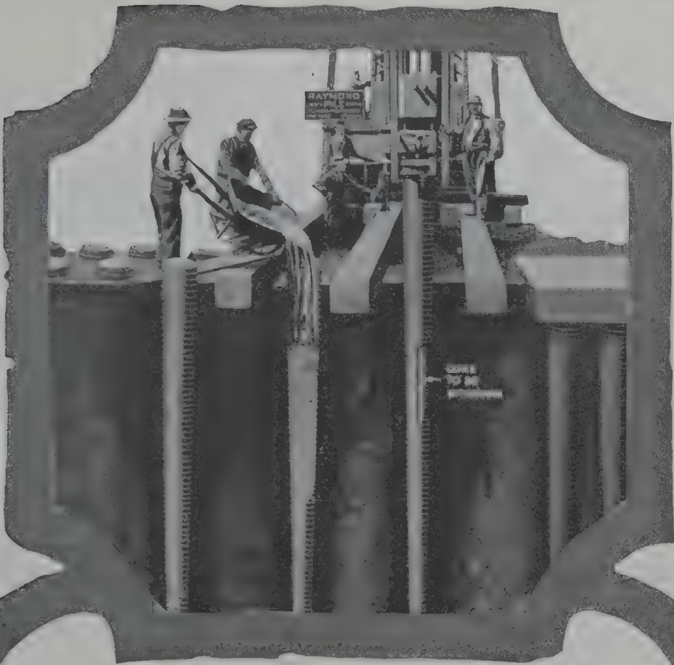
ATLANTA
Candler Building

PITTSBURGH
First Nat. Bank Bldg.

CLEVELAND
1525 Guardian Bldg.

CHICAGO
Peoples Gas Bldg.

SAN FRANCISCO
Monadnock Bldg.



THE
RAYMOND METHOD
of
Concrete Pile Installation

was chosen by the Engineers for the ARMY SUPPLY BASES at BOSTON, NEW YORK and NEW ORLEANS, because it makes absolutely certain that each and every concrete pile is perfect. A spirally reinforced steel shell is driven by a driving core, or mandrel. The core is then collapsed and withdrawn, leaving the shell in the ground. The interior of this shell may then be inspected; and finally the concrete is poured into it, the shell remaining in place to protect the pile column. ℭ We also construct Special Reinforced Concrete Work of every description: Shipbuilding, Ways, Docks, Bridges, Retaining Walls, Piers, Ore Handling Structures, etc.

RAYMOND CONCRETE PILE COMPANY

NEW YORK: 140 Cedar Street CHICAGO: 111 W. Monroe Street
MONTREAL, CANADA: Raymond Concrete Pile Co., Limited
BOSTON: 80 Boylston Street

A Form for Every Pile *A Pile for Every Purpose*

T. Stuart & Son Company

General Contractors

NEWTON, MASSACHUSETTS

Bay State Dredging & Contracting Co.

Contractors

River and Harbor Improvements, Sea Walls, Breakwaters, Heavy Masonry Construction.

62 Condor St., East Boston, Mass.

JAMES E. CASHMAN, Treas.
GORHAM H. WHITNEY, Prest. DAVID J. WHITE, Sec'y—Gen. Mgr.

KEARNS CONSTRUCTION COMPANY

CONSTRUCTING ENGINEERS

153 MILK STREET - - - BOSTON, MASS.

1920 promises to be the most remarkable building construction period this country has ever known.

Tremendous activity in industrial projects is already evident.

Present conditions fail to indicate any downward trend in building costs.

We suggest early consideration of anticipated operations by prospective owners.

We were the pioneers and are still the leaders in reinforced concrete construction.

We place at your disposal KEARNS SERVICE, backed by the experience of more than twenty-five years of successful building.

KEARNS SERVICE MEANS THE BEST IN INDUSTRIAL BUILDING CONSTRUCTION

SPECIAL COMMITTEES

ON THE LIBRARY

S. EVERETT TINKHAM, Chairman
HOWARD B. LUTHER
EDWARD H. ROCKWELL

ON MEMBERSHIP

SAMUEL P. WALDRON, Chairman
JOHN B. BABCOCK, 3d
JOHN E. L. MONAGHAN
FRANK B. WALKER
JOHN P. WENTWORTH

ON PUBLICATION

STURGIS H. THORNDIKE, Chairman
HAROLD K. BARROWS
HENRY B. WOOD

ON PAPERS AND PROGRAM

FRANK A. BARBOUR, Chairman, ex officio
GORDON M. FAIR
FRANK A. MARSTON
GEORGE E. RUSSELL
SANFORD E. THOMPSON
S. EVERETT TINKHAM
LEONARD C. WASON
GEORGE A. SAMPSON

RATES FOR ADVERTISEMENTS

For one year — 10 issues

One page	$75.00
One-half page	40.00
One-quarter page	25.00
One-sixth page	17.50
One-eighth page	14.00
One-twelfth page	10.00

Last page, 50 per cent. additional.

For further information, or for contract forms, address

WILLIAM L. BUTCHER, Editor
715 Tremont Temple, Boston

SAMUEL USHER
BOSTON